CORRUGATED TUBING DIG

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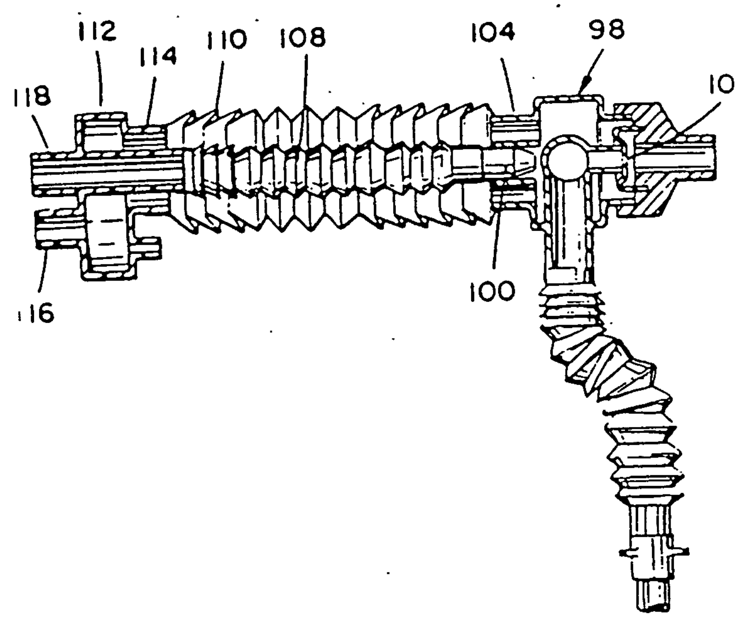

(57) Abstract

The patient connection of a respiratory gas system includes a corrugated connection element (20) between the patient's manifold (16) and the endrotracheal tube (18) or other delivery element. The element's walls are formed into special corrugations which can assume any of three relaxed states. In one state the corrugations are compressed. In a second state the corrugations are extended and in the third state the corrugations have the first state at one region of the corrugation and have the second state at the diametric region of the corrugation. Lengths of the specially corrugated tubing may be substituted for conventional tubing to the end that circuit runs may be shortened and lengthened as needed to reduce the number of different lengths required in respiratory circuits kits and to optimize the arrangement of the flow conduits in respiratory circuits.

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RESPIRATORY SYSTEM CORRUGATED FLOW LINES AND FITTINGS

Field of the Invention

This invention relates to improvements in the circuit elements of respiratory systems and it relates in particular to corrugated flow lines and coupling members in systems whose purpose is to furnish respiratory gas to patients.

Background Art

A generalized model of a respirator system includes a source of humidified, pressurized, respiratory gas connected by a gas delivery conduit to a system element which supplies inspiratory gas to the patient, and which receives expiratory gas from the patient. The general model includes a conduit by which the expired gas is drawn to a suction point. In actual systems the source and the return point form part of a respirator or ventilator which serves to control composition of the gas, supply and return pressure, gas temperature, humidity, and the frequency of supply pressure variations. The system element by which gas is delivered to the patient may be a tent or an incubator or a mask or a flow manifold and nasal or endotracheal tube. The respirator is portable and is positioned next to the subject's bed or incubator such as to permit connection to sources of electrical power, water, oxygen and the like.

The respirator is brought to the patient and his/her delivery structure is connected to the machine by flexible supply and exhaust tubing. In its details, each interconnection is unique. The distance and angle from the

respirator to the patient are unique for each instance. The ambient humidity and temperature, and the means for preventing excess sagging in the delivery and exhaust lines, and the arrangement for holding the mask or endotracheal tube in place, and the need for condensate traps, and the desire to keep system compliance to a minimum, especially for infant patients, and more, must be newly taken into account in creating the respiratory circuit for each patient. To aid the respiratory therapist or physician in establishing a satisfactory circuit, tubes and traps and connectors and fittings in a variety of lengths and sizes are sometimes packaged together as a kit of parts or as an assembly with extra parts. The practitioner selects and interconnects pieces from the kit or assembly to create the breathing circuit. What remains is disposed of as unused excess. The amount of the excess is often very significant because the assemblies and sets are arranged to accommodate a variety of types of equipment and treatments and sizes of patients.

The tubing constitutes a major part of most sets. To permit bending without kinking it is almost invariably corrugated along its length except at the ends and it is formed of a resilient material. That introduces two problems. The tube cannot be "cut to fit". Instead, the kit includes tubes of different lengths to insure that one will be sufficiently long. Not only is the practice wasteful of tubing material, it is wasteful of storage space at manufacture and at the facility at which it is to be used. It is wasteful, too, of shipping facilities because the bulk far exceeds the weight of the tubing, and the cost of shipping (which is computed on bulk) can be an important part of the eventual cost to the patient who must pay for the kit. cost

The prior art corrugated tubing gives rise to additional problems. To permit bending without kinking requires a compromise. To bend on a smaller radius requires larger corrugation diameter with respect to the tube inner diameter and heavier tubing walls. The result is increased renitency and greater difficulty in creating flexible circuitry and in avoiding application of force to the patient and increased tubing diameter and compliance. For example, it cannot be used to complete a short, low compliance connection from the respiratory flow line manifold to the endotracheal tube of a premature infant. Rigid couplings have been used for that purpose and if bending is required at an angle for which there is no rigid elbow, rigid, universal swivel joints are used.

What is needed for adult and infant respiratory circuit systems alike is a circuit element which, unlike resilient corrugated tubing, will not kink or collapse under hospital use conditions, whose length can be increased or decreased without cutting or substitution, which exhibits a resilience to permit draping but which can be bent on a very small radius without exhibiting renitency to oppose the bending, and which can be returned to initial condition after having been bent and then rebent if desired. Such an element would require only a fraction of the storage and shipping space now required and it could replace a number of the tubes, elbows, swivels and universal joints currently in use. Such an element is what the invention provides and its cost is no greater than the cost of the old tubing and, in some cases is less than the cost of the rigid elements it replaces.

Disclosure of Invention

It is an object of this invention to provide improved, more functional respiratory gas flow circuit elements.

Another object is to provide elements for respiratory gas flow circuitry which can be use to create circuits which employ fewer parts and fewer interconnections and potential leak points while permitting reduced flow resistance and reduced circuit compliance, more efficient control of condensate, and more easily managed and less uncomfortable connection to the patient than usually is possible with corresponding prior art elements.

Another object is to provide such an element which can swivel and rotate through complete revolutions relative to another adjacent element without a resilient bias and without loss of sealing against leaks.

A further object of the invention is to provide flow circuit elements which require only a fraction of the storage and shipping space required by conventional circuit elements.

One of the specific objects of the invention is related to the fact that the muscular activity that results is breathing is triggered by carbon dioxide levels in the lungs. Frequently when a patient is ventilated, the carbon dioxide level falls to a level so low that the patient does not breath of his own accord. The level can be raised without disturbing system pressure buy lengthening the connection from the patient to the coupler in the supply and return circuit. The invention provides a novel means for adjusting that length and, in the preferred

form, for increasing volume in that connection with a minimum change in length.

These and other objects and advantages of the invention result in part from the use of a special corrugation design for the walls of tubes and connectors in which one side of individual corrugations are more wide than the other whereby in combination with the other the wider side has the characteristics of a Bellville washer. The corrugation design is such that the two sides of the corrugation are stable or relaxed in either of two, and in the preferred form, any of three states or relative positions. The two sides of each corrugation are joined at their common outer periphery by a hinged connection. In one relaxed condition the two sides lie nearly parallel over their whole circumference. In a second relaxed condition the two sides diverge from their hinged connection over the whole of their circumferences. In the third relaxed condition, at one region on the periphery of the corrugation the sides have the first of these relaxed conditions whereas at the diametric region the two sides are in the second relaxed condition. The result is that the respiratory circuit element may be compressed to stable, shorter length or elongated to stable, longer length or bent to a stable curve of selected simple or compound radius.

A major advantage of the invention is that it can employ thin and relatively rigid plastic material. Elements like water trap connections and patient couplers or manifolds can be molded integrally with input and output tubes and patient connection tubes. These combination elements can be formed in blow molds, for example, with flow ports closed to be trimmed open as needed when the therapist constructs the breathing circuit.

Brief Description of the Drawings

In the drawings:

Figure 1 is a diagramatic showing of a representative respiratory system and patient in an intensive care unit;

Figure 2 is a length of respiratory tubing according to the invention, part of the special corrugations being and others compressed;

Figure 3 is an enlarged cross-sectional view of the tube of Figure 2 taken at the junction of its extended and compressed portions;

Figure 4 is a cross-sectional view of one preferred form of respiratory gas system in which the invention is embodied;

Figure 5 is a view in side elevation of another preferred respiratory system circuit in which the invention is embodied;

Figure 6 is a cross-sectional view of the manifold taken on line 6-6 of Figure 5.

Figure 7 is a view in top elevation of a fragment of a unitary assembly made possible by an incorporation of the invention;

Figure 8 is a cross-sectional view taken on line 8-8 of Figure 7;

Figure 9 is an isometric view of the upper container portion of a water trap;

Figure 10 is a cross-sectional view showing how the water trap may be assembled of the assembly of Figure 7;

Figure 11 is a top plan view, reduced in size, of the assembly of Figure 7 illustrating how it can be used;

Figure 12 is an enlarged cross-sectional and fragmented view taken on line 12-12 of Figure 11; and

Figure 13 is a further enlargement of a portion of Figure 12 to illustrate more clearly how the sealing annulus is employed.

Description of the Preferred Embodiment

Figure 1 illustrates one of the many physical arrangements by which a patient 8 can be connected to a respiratory gas supply system. The showing is largely schematic.

The apparatus 10 is the respirator. It is often called a ventilator and its function is to provide an adequate flow of pressurized and humidified respiratory gas, usually a mixture of air and oxygen, to a patient manifold and to receive excess gas and exhaled gas from the manifold. The supply conduit is numbered 12 and the return conduit is numbered 14: They connect to the patient manifold 16. The manifold includes a chamber through which the supply gas flows.

The patient's trachea and lungs are "connected" or "attached" to the chamber by an application apparatus of some kind and a flow connector. The application apparatus may be a mask or tracheotomy or an endotracheal or nasal tube. In this case it is an endotracheal tube 18 and it is connected to the manifold 16 by a flow connector 20. Both supply and return lines include a water trap one (22) of which is visible.

The manifold, connector, and tube are shown enlarged in Figure 5. The endotracheal tube 18 is standard and does not form part of the invention but its inclusion illustrates the importance of the special manifold and connector combination. The respiratory gas usually is furnished in heated condition and at or near one hundred percent humidity. If there is any cooling, water will be condensed out of the gas. To prevent the condensate from reaching the patient the system will in-

clude water traps. A common practice is to drape the supply and return conduits and to include a trap in the sagging portion of the line. Whatever the arrangement for trapping the condensate, it will serve to limit the amount of movement permitted to the manifold and it will limit variation in manifold orientation. In the past none of the movement of the patient was accommodated in the connection between the manifold and the endotracheal tube or airway except to the extent that the flexible tube could be bent or insertion of a a rigid and complex swivel joint could be accommodated. Bending was necessarily limited because one of the requirements of many ventilating systems is that tube length be short whereby dead air space is minimized. If it is not minimized, the exhaled gas remains in the connector between the tube and the manifold to be returned to the patient in the next inspiratory cycle. The ideal is to minimize the volume of the manifold, to make the connection from the manifold very short, and to incorporate a means to permit entirely free movement of the manifold sufficient to accommodate all horizontal and vertical movement of the patient. The object is to avoid discomfort and to insure that coughs, jerks and spasms do not cause the patient to extubate himself or to pull a circuit connection apart. Entirely free movement cannot be achieved. However, it is possible to permit not only side to side motion of the manifold relative to the patient but to permit the separation of manifold and patient to vary in some degree. That is what is permitted in the invention. The corrugations of the connector 20 are special in that they provide greater lateral flexibility than a smooth tube of the same diameter and much greater lateral flexibility than a conventional corrugated tube. Perhaps even more important, the special corrugations permit the connector to become longer and shorter as the manifold 16 and tube 18 are moved

closer together and farther apart by movement of the patient.

That result can be achieved because the connector 20 can be shortened by collapse of its corrugations and it can be extended by extension of its corrugations. Moreover, that greater freedom of movement is achieved in part because the connector can be bent on a small radius by collapsing individual corrugations on one side and extending them on the other side of the connector without renitency. In the preferred form the individual corrugations can assume any of three relaxed, stable conditions and the material of which they are formed has sufficient stiffness and renitency to urge the corrugation into one of those relaxed conditions and to respond to external force to change from one to another of the relaxed states with a snap action. The corrugation walls between the inner and outer circular hinges must be relatively stiff. The hinges themselves need to be quite flexible. The walls must have enough resilience to bend and warp because snap action utilizes over center spring action. The art of corrugation molding is sufficiently advanced so that given a predictable plastic such, for example, as polypropylene an effective combination of material and wall thickness is readily found.

In Figure 6, the manifold 16 has a lower face 24 and an upper face 26 and a cylindrical side wall 28. The supply gas is introduced at an inlet port 30 and exhaust flows out of the manifold at an outlet port 32. In this case the inlet and outlet ports are located on the upper face 26 of the manifold although either or both could have been located on the side wall 28. Cylindrical fittings 34 and 36 afford communication with ports 30 and 32, respectively, and the cavity 38 of the manifold. Two more

fittings, one 40 for a pressure sensor and one 42 for a temperature sensor, are visible in Figure 5.

The several corrugations of connector 20 include at least one in each of the three relaxed states. However, that is true too of the length of tubing 44 shown in Figures 2 and 3. In Figure 2 tube 44 has a cylindrical fitting 46 at its left end. Adjacent to that fitting is a section 48 which is corrugated in conventional fashion. The remainder of the tube, to the cylindrical fitting 50 at the right end, is formed with its wall specially corrugated. The several corrugations of the group 52, including corrugations 54 and 56, have the first relaxed state in which the two sides of the corrugation lie somewhat parallel. The next two corrugations, 58 and 60, have the second relaxed state in which the sides of the corrugation are divergent from their hinged interconnection at their common outer diameter. The next several corrugations including the three numbered 62, 64 and 66, respectively, are in the third of the relaxed conditions. At one side of these corrugations, the upper side in Figure 2, the two sides diverge in the second relaxed condition. At the other side of the corrugation the two sides lie approximately parallel in the second relaxed condition. The remaining corrugations of the tube are in one of the three relaxed states.

Any of the special corrugations can have any one of the three relaxed states if the tube is made of stiff material that is sufficiently rigid to resist change from one state to another unless subjected to external force.

A special corrugation according to the invention is formed by two annular sides which have hinged interconnection at their common outer diameter. Thus cor-

rugation 54 has sides 68 and 70 which are joined at circular hinge 72. The two sides 68 and 70 lie somewhat parallel to one another in first relaxed state. The two sides 68 and 70 have a common outer diameter and equal inner diameters. Side 68 is wider from its inner to its outer diameter than side 70 is wide. Conversely, side 70 is narrower than side 68. If the narrower side 70 is subjected to a force tending to pull it to the right and if the inner hinged connection 74 to corrugation 56 is stretched through smaller diameter, the hinged connection will be pulled to a position to the left of the plane of the outer hinged connection 72. It will have been pulled over center and the renitency of the tube material will urge the inner hinge 74 to move to the right in Figures 2 and 3 to the second relaxed state. That has been done in the case of corrugations 58 and 60. Referring to corrugation 58, its sides 86 and 88 diverge from one another at the outer hinged connection 90.

In the case of corrugations 62, 64, 66 and some of the other corrugations between corrugation 66 and the right end connector 50 of Figures 2 and 3, the inner hinged connection between adjacent corrugations has been stretched beyond the yield point by bending the tube to warp that inner hinged connection. The result is that the outer side of the corrugation is in relaxed condition two and the inner side is in relaxed condition one. As a consequence these convolutions no longer can have the first relaxed condition. They can have states two and three. The result is greater lateral flexibility in the connector and a tendency, unless these corrugations are pulled to the second state, for the bend to be more permanent.

One of the advantages of the special convolutions is that they are easy to form. The forming tool has the negative of the inner shape of the finished tube when all convolutions are in the second relaxed state. The forming process is the same as it is for conventional corrugated tubing. The preferred tubing material is a polypropylene plastic. That material is relatively very stiff compared to prior art breathing tubes. The amount of force required to make it change from one state to another is a function of stiffness, inside and outside diameter of the corrugations and widths of the corrugation sides. For example, a representative, specially corrugated tube has an inside diameter of 0.48 inches, outside diameter of 0.68 inches, a slope relative to the tube axis of thirty degrees at the wide side and at the narrower side a slope of negative 80 degrees. It is formed of polyethylene 0.005 inches thick and has a tensile strength of 4900 psi at 2"/minute and secant flexural modulus of 160,000 psi at .05"/minute.

The individual convolutions are about three times as wide in their state two condition as they are in state one. Neglecting the end connectors, tube length can be increased and decreased by a factor of three. The saving in shipping and storage volume is as important in some cases as is the flexibility and versatility the invention adds to the patient connection element. Also important is the facility for optimizing the arrangement of the supply and return lines between the respirator and the patient manifold. The need for a number of tubes of different length is minimized. Circuit runs may be more direct and are more readily arranged to collect condensate at a convenient and accessible point. The special corrugations are collapsed to minimize circuit length and system compliance. An example of the utility of the inven-

tion is shown in Figure 4. This circuit is especially suited to the ventilation of neonates. The patient manifold 98 includes means for high frequency pulsing of manifold pressure while maintaining pressure during exhalation phase at or very near atmospheric pressure. The nozzle 100 and the exhalation valve 102 are part of that means. Respiratory gas enters at the nozzle and exhaust gas is drawn off through the exhalation valve to an outer, encompassing flowpath that ends at the cylindrical fitting 104. The latter is concentric around the nozzle 100. The patient manifold 98 is connected by coaxially arranged inner supply conduit 108 and outer return conduit 110, to a respirator end water trap and manifold 112. Manifold 112 includes a cylindrical return conduit fitting 114 which communicates through the manifold with a cylindrical exhaust fitting 116. A cylindrical supply fitting 118 is formed through the cavity of the manifold on the axis of fitting 114. Conduits or tubes 108 and 110 are formed with the special convolutions. There is no need to match them or cut them to matching length. They can be assembled with the manifolds easily by extending the corrugations of the inner conduit and compressing those of the outer conduit while connecting the ends of the inner one to nozzle 100 and fitting 118. Thereafter the inner conduit is collapsed enough to permit assembly of the outer conduit on fittings 104 and 114. Once the conduits are secure on their end fittings their length is readily adjusted over a relatively wide range by bringing the manifolds together or moving them apart. What could be a difficult assembly task is made simple and easy. In use the coaxial pair exhibits much more flexible or "moveable" at the patient manifold than is possible to achieve with conventional soft tubes.

It is to permit bending without collapse or kinking, and to resist crushing that tubing is corrugated. In prior art tubing the price for that combination of attributes is the renitency that opposes bending. That price need not be paid in the case of the invention. Respiratory system elements made according to the invention are far more crush resistant. The importance of that is particularly apparent in anesthesiology. During surgical procedures the breathing circuit is often covered with surgical towels. Out of sight, the tubes get leaned on and squashed by other apparatus and by members of the operating team.

The quality that length may be changed does more than permit cost saving. In the case of the connection between the patient manifold and the patient, the ability to change volume in that connection provides an easy way to change the ratio of fresh to rebreathed gas in the inspiratory phase. But there are other important advantages.

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Because the tubing material is relatively rigid, it is possible to combine tubing and other circuit elements in a unitary assembly. A particularly useful combination includes the patient manifold and the supply and exhaust tubing that connects to the manifold. Another is the combination of the patient manifold and the patient connection tubing. An example of the former is shown in Figure 7. This assembly, generally designated 130, includes a patient manifold 132 at the midregion of its length. Above the manifold, in order, are a tube section 134, a water trap manifold 136, another tube section 138 and a cylindrical end fitting 140. In order below the manifold are a tube section 142, a trap manifold 144, another tube 146 and an end fitting 148. Each of the

three manifolds is formed with four generally cylindrical cups extending from the outer periphery of the manifold each cup perpendicular to those on either side and all in a common plane perpendicular to the central axis of their respective manifolds. They are cups because they are molded with their outer ends closed in the preferred method. That makes it possible to employ the inexpensive blow mold process to produce the unit. Any one of the cups is readily converted to a connector fitting by snipping off of the closed end.

The four tubing sections all employ the special construction of the invention. For identification, the upper cup of the patient manifold 132 is numbered 150. The one on the left, 152 and the one on the right 154. The lower cup, its end clipped to form a fitting, is numbered 156 and is visible in Figure 12.

The preferred patient manifold is symmetrical about the plane parallel to the paper, in the drawing, and to the plane perpendicular to the paper which planes contain the longitudinal center line of the unit. Thus any one of the cups may have its outer end removed and serve as the fitting for attachment to the patient connection tube. The preferred manner of attachment is shown in Figure 12. Consistent with the molding process, the cups are tapered to lesser diameter in the direction away from the interior of the manifold. That "draft" facilitates removal from the mold. The mating connector 158 in Figure 12, has an inverse taper. In a conventional connection, the fitting that tapers to smaller diameter is fitted inside the one that is tapered or flared outwardly.

The opposite arrangement is employed in the preferred embodiment of the invention. The flared one is the

female part. It is encompassed and resiliently embraced by an elastic sealing annulus which in this case is an O-ring 164. In this case the flared fitting is the upper end of an extensible patient connection tube 166. The interconnection between fittings 156 and 158 can be tightened by pulling the tube downwardly in Figure 12 relative to the coupler 132. However, in practice that may do more to prevent rotation of tube 166 than to prevent the leakage of gas at the joint. Slight offset of the molding tool halves and flash, even if tool alignment is exact, results in discontinuities on the outer surface at the parting line of the tool. The relatively soft O-ring is indented by those discontinuities without loss of sealing action. The tube 166 is formed with a shoulder or the like at the base of fitting 158 such that the O-ring is biased into engagement with the outer end of fitting 156 to complete the seal. The preferred construction is shown in Figure 13.

The two fittings need not be drawn tight but the tube is left free to rotate relative to the manifold. The result is that 360 degree rotational freedom is added to the adjustable extension and bias free bending of the tube to provide structural flexibility previously unknown in respiratory circuitry.

The cups 150 and 154 have been left intact in Figure 12. The ends of one or both, and the end of the fourth cup 162, can be cut off to accommodate pressure and temperature sensors and gas sample fittings if the therapist desires.

Manifolds 136 and 144 differ from manifold 132 in that the cups at the sides of the assembly are smaller and shaped differently than are the upper and lower cups.

That is best seen in the cross-sectional view of Figure 8. As in the case of Figures 10 and 12, the wall thickness has been exaggerated for the sake of clarity. The small side cups 170 and 172 are intended as fastening elements to which hanger straps may be buttoned or otherwise attached. They are used that way in Figures 10 and 11 to hold a pair of water traps in place. A trap 174 is fixed to manifold 136 and a trap 176 is fixed to manifold 144. Fig_re 10 is a view in central section taken through manifold 144 and trap 174. The trap is a modified version of the trap shown in our United States Patent No. x,xxx,xxx. It is formed by two containers 178 and 180. Upper container 178 is press fitted into the lower, cup-shaped container 180. The upper one is fitted with upwardly extending straps 182 and 184 as best seen in Figure 9. Diametrically placed at the sides of the container 178, the straps are buttoned to the manifold. Strap 186 is secured by its buttonhole 186 to button 190 of container 188. Strap 192 is secured by its button holes 194 and 196 to button 198 and upper cup 200, respectively, of the manifold.

Communication between the manifold and the trap is afforded by the combination of lower fitting (clipped cup) 202 which fits over fitting or neck 204 of container 178. Except that air tightness is not required and the O-ring is omitted, the connection here is the same as what is depicted in Figure 12.

Being tapered, the open end of the neck 204 has larger diameter than the diameter of the open end of fitting 202. The container 178 is, or may be, formed of the same material as the manifold 132. Its neck may have its wall indented as it is shown to be in Figure 9 at 206 and in that condition it is easily inserted into the

fitting 202. Once inserted, the indentation is released. The neck snaps back to circular shape and connection is completed.

Integral formation of the supply and exhaust tubing with the patient manifold is important for the low cost, leak proof nature, and versatility it affords. It is practical because the tube portion can be made of material having the rigidity required in the manifold. Inclusion of the water trap manifolds is practical because tubing length and shape readily adjusted. The traps need to be located at or near low points. That is easily arranged in the invention because the tubes are readily bent to a configuration in which the trap manifolds are low.

While certain embodiments have been shown in the drawings and described in accordance with the rules requiring disclosure of the best embodiment of the invention, other embodiments and modifications are possible within the invention. It is to be understood that the invention is not limited to what is shown but is to be limited only by the scope of the appended claims.

The Claims

I claim:

1. A respiratory gas circuit element comprising a length of tubular conduit having a series of annular corrugations formed in the conduit wall;

a plurality of adjacent ones of said corrugations each having two sides said sides having hinged connection to one another at their common outer periphery and having like inner diameters;

one of said side walls being wider than the other;

said side walls and said hinged connection having sufficient flexibility and resilience to permit the sides to move from a first stable position, in which they lie substantially parallel, to a second stable position in which said walls diverge from one another at said hinged connection; and

said side walls having sufficient renitency to bias said sides to tend to remain stable in either of said first and second positions.

2. The invention defined in claim 1 in which said sides have sufficient bias against warping to maintain the narrower side in a third stable condition in which one region of said sides lie nearly parallel in said first stable condition and in which at a diametric region said sides are divergent in their second stable condition.

3. The invention defined in claim 2 in which said tubing is formed of a semi-rigid material such that the forced transition of the sides of the corrugations from one stable condition to another occurs with a snap action.

4. The invention defined in claim 2 in which adjacent ones of said special corrugations are joined by an inner hinged connection of the wider side of one corrugation with the narrower side of the succeeding corrugation at their inner diameter;

and in which the tubing material can be stretched beyond its elastic limit manually at the inner hinged connection between adjacent corrugations by extension of their inner hinged connection in the direction of the tube axis and by bending the tube at the juncture of said adjacent corrugations to the end that the corrugation whose narrower side is joined at said inner hinge will not remain in said first stable condition.

5. The invention defined in claim 2 which further comprises a respiratory gas flow manifold housing a chamber, a flow port and a fitting at the manifold's lower face, inlet and outlet ports each with an associated fitting and each at a face of the manifold other than said lower face, the fittings affording communication to said chamber through its respectively associated port;

one end of said tubular fitting being connected to the fitting at said lower face of the chamber.

6. In a respiratory gas circuit of the kind which includes a manifold for inclusion in series in the supply to exhaust line and a connector for connection to a mask or endotracheal tube and an interconnection element between the manifold and the connector, the improvement in which:

said interconnection element is a length of tubular conduit having a series of annular corrugations formed in the conduit wall;

a plurality of adjacent ones of said corrugations each having two sides said sides having hinged connection to one another at their common outer periphery and having like inner diameters;

one of said side walls being wider than the other;

said side walls and said hinged connection having sufficient flexibility and resilience to permit the sides to move from a first stable position, in which they lie substantially parallel, to a second stable position in which said walls diverge from one another at said hinged connection; and

said side walls having sufficient renitency to bias said sides to tend to remain in one or the other of said first and second positions.

7. The invention defined in claim 6 in which said sides have sufficient stiffness to maintain the narrower side in a third stable condition in which one region of said sides lie nearly parallel in said first stable condition and in which at a diametric region said sides are divergent in their second stable condition.

8. The invention defined in claim 7 in which said tubing is formed of a semi-rigid material such that the transition of the sides of the corrugations from one stable condition to another occurs with a snap action.

9. The invention defined in claim 7 in which adjacent ones of said special corrugations are joined by an inner hinged connection of the wider side of one corrugation with the narrower side of the succeeding corrugation at their inner diameter.

10. The invention defined in claim 9 in which the manifold houses a chamber and includes a flow port and a fitting at the manifold's lower face, inlet and outlet ports each with an associated fitting and each at a face of the manifold other than said lower face, the fittings affording communication to said chamber through its respectively associated port;

one end of said interconnection element being connected to the fitting at said lower face of the chamber.

11. In a respiratory gas circuit of the kind which includes a manifold for inclusion in series in the supply to exhaust line and includes an interconnection element for connection to a patient to the manifold, the improvement in which said interconnection element is selectively adjustable in volume by alteration of its length to any of a plurality of lengths.

12. The invention defined in claim 11 in which said manifold and said interconnection element are integrally formed.

13. The invention defined in claim 12 in which said interconnection element comprises a corrugated tube the corrugations of which are interconnected and hinged to succeeding corrugations at the inner diameter of their adjacent sides, the corrugations being formed such that their sides may assume a first stable condition in which they lie nearly parallel and, alternately, a second stable condition in which the sides diverge.

14. A breathing circuit element in the form of a corrugated tube the several corrugations of which are hingedly interconnected to adjacent corrugations at their common inner diameter and the sides of which corrugations are hingedly interconnected at their common outer diameter such that the sides of a corrugation will lie adjacent to one another in a first stable condition or divergent from one another in a second stable condition.

15. The invention defined in claim 14 in which the condition of said sides may be changed selectively in the several corrugations independently of the condition of other corrugations.

16. The invention defined in claim 15 in which the condition of the sides of the corrugations is changeable between said first and second conditions with snap action.

17. The invention defined in claim 14 which further comprises a manifold having at least two ports and in which said tube and said manifold are integrally formed such that the interior of the tube is in communication with the interior of said manifold by way of one of said ports.

18. The invention defined in claim 17 which further comprises a second such tube which is integrally formed with said manifold and whose interior communicates with the interior of the manifold by way of the other of said two ports.

19. The invention defined in claim 17 which also comprises a fitting integrally formed with said manifold such as to afford communication to the interior of the manifold via the other of said two ports;

the fitting being generally cylindrical about a central axis and tapered to smaller diameter in the direction away from the interior of the manifold;

a further breathing system element comprising an

end fitting assembled in said fitting first mentioned and being tapered to increasing diameter in the direction of the interior of said manifold.

20. The invention defined in claim 19 which further comprises an elastic sealing annulus embracing said second mentioned fitting adjacent the end of said first mentioned fitting.

21. In a breathing circuit, two circuit elements each formed with a fitting interconnectable with said fitting of the other, one fitting being tapered at its interior to smaller diameter in the direction away from its respectively associated circuit element and the other having an exterior taper complementary to the interior of said one fitting; and

an elastic sealing annulus elastically embracing said other fitting at its smaller diameter end.

22. The invention defined in claim 21 in which said fittings are assembled such that the second is disposed in the first and said sealing element embraces the second and bears against the small diameter end of the first.

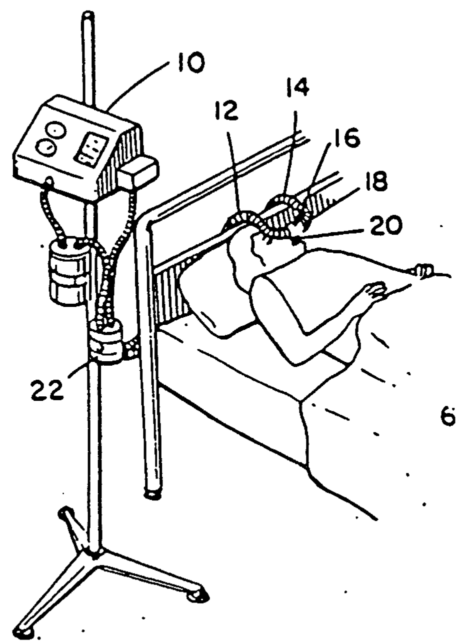


FIG. 1

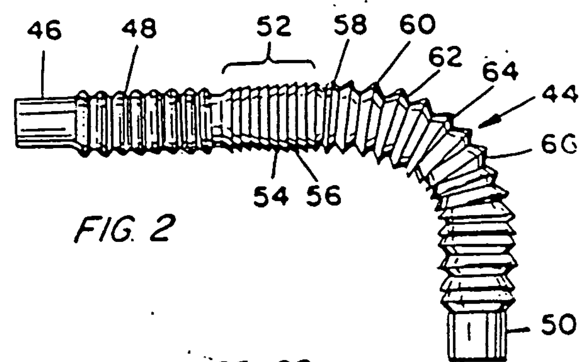


FIG. 2

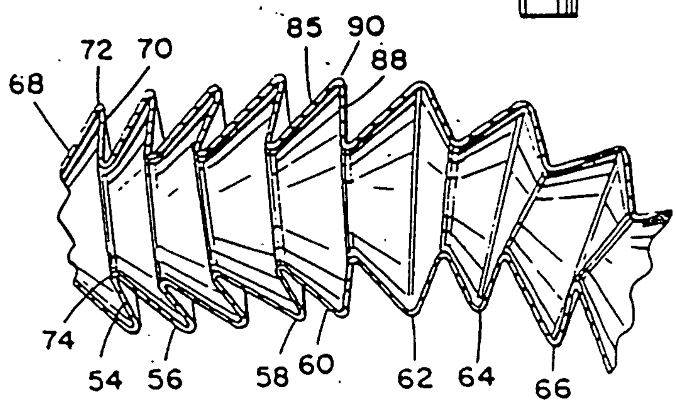


FIG. 3

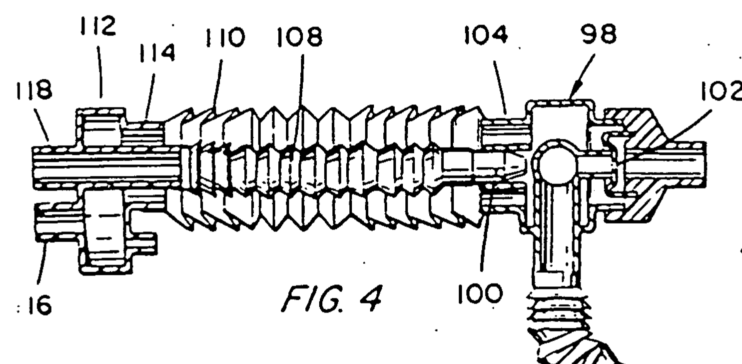


FIG. 4

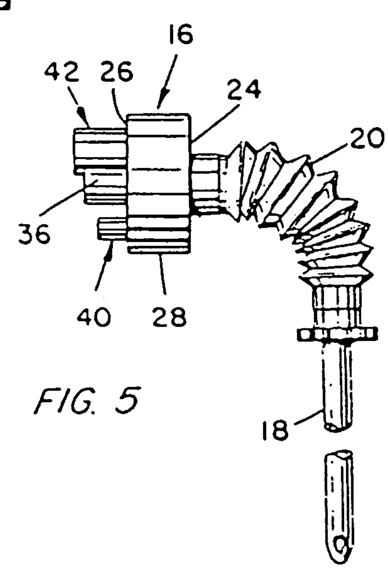


FIG. 5

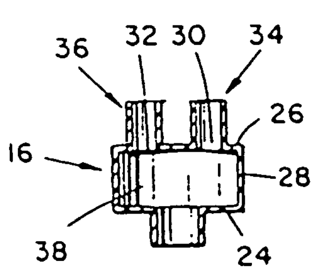


FIG. 6

FIG. 10

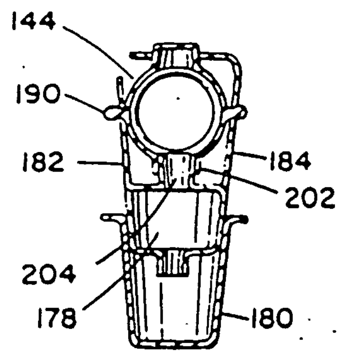


FIG. 8

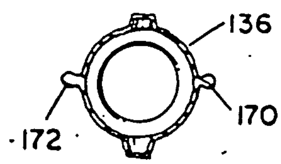
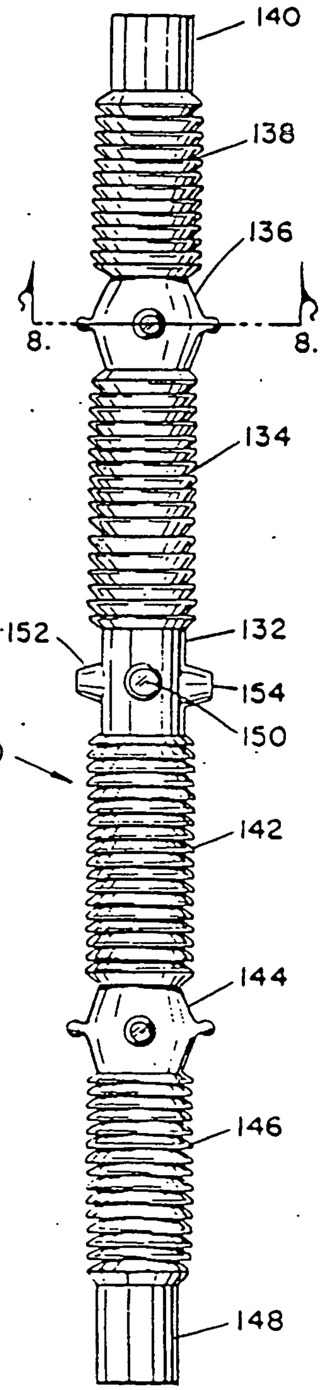


FIG. 7



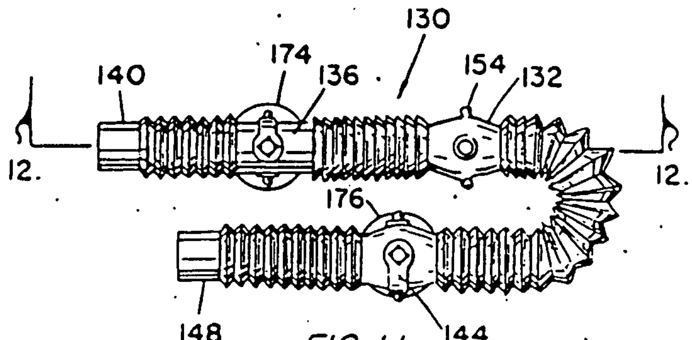
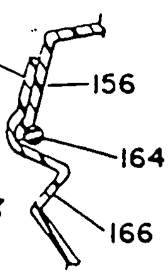


FIG. 11

FIG. 13



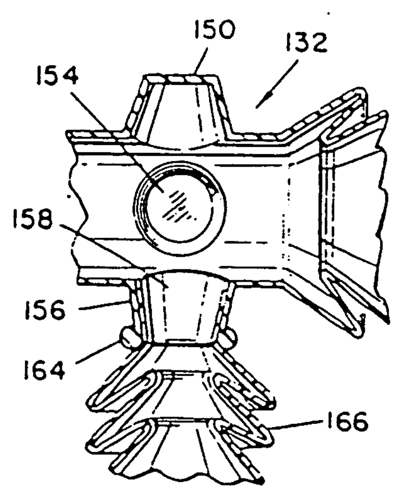
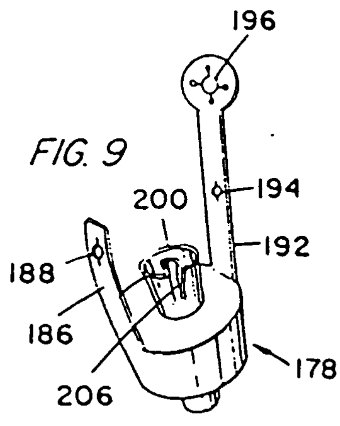


FIG. 12

FIG. 9



[INT]ERNATIONAL SEARCH REPO[RT]

International Application No PCT/US84/01323

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC 3 A61M 16/00
U.S.CL

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S	128/204.18,Dig26,911,204.18,207.14,207.15,207.18 138/119,121 285/260,332,189,Dig4.

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	U.S., A, 4,275,724 30 June 1981 BEHRSTOCK	1-10,13-20
Y	U.S., A, 4,363,323 14 December 1982 GEISS	1-10,13-20
Y	U.S., A, 4,050,466 27 September 1977 KOERBACHEN	1-10,13-20
Y	U.S., A, 3,388,705 18 JUNE 1968 GROSSHANDLER	1-10,13-20
Y	U.S., A, 4,360,104 23 November 1982 LANG	1-20
Y.	U.S., A, 3,929,165 30 December 1975 DIEBOLT, et al	1-10,13-20
Y	U.S., A, 3,908,704 30 September 1975 CLEMENT, et al	1-10,13-20
Y	U.S., A, 3,409,224 05 November 1968 HARP, et al	1-10,13-20
Y,P	U.S., A, 4,456,008 26 June 1984 CLAWSON, et al	5-13,17-20
Y	U.S., A, 4,037,862 26 July 1977 THORP, et al	19-22
Y	G.B., A, 549,361 18 November 1942 SMITH	19-22
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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [9]
29 OCT 1984	30 OCT 1984
International Searching Authority [1]	**Signature of Authorized Officer [10]**
ISA/US	[signature]